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Environmental and Operational Mid-Year Data Report for the OU 7-08 Organic Contamination in the Vadose Zone Project – 2003

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September 2003

Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho, LLC

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Approved

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ABSTRACT

Since January 1996, Operable Unit 7-08 has been using soil vapor extraction to remove organic contamination from the vadose zone outside the disposal pits and trenches in the Subsurface Disposal Area within the Radioactive Waste Management Complex at the Idaho National Engineering and Environmental Laboratory. The vadose zone contains volatile organic compounds, primarily in the form of organic vapors that have migrated from buried waste in the pits and trenches.

This report documents operational and sample data for Operable Unit 7-08 recorded between January 1 and June 30, 2003. During that time, approximately 4,987 kg (10,995 lb) of total volatile organic compounds were removed from the vadose zone and oxidized through thermal or catalytic processes. Vapor vacuum extraction with Treatment Units A, B, and D removed approximately 3,902 kg (8,603 lb), 234 kg (515 lb), and 852 kg (1877 lb), respectively.

Carbon tetrachloride is the largest contributor to the volatile organic compound mass removal, representing 57% of the total for this operating cycle. Isoconcentration plots of current carbon tetrachloride vapor data, at a depth of approximately 21 m (70 ft), indicate an overall decrease in the areal extent of the plume when compared to data taken before operations at the same depth. Data also suggest a decrease in carbon tetrachloride concentration at the center of the plume.

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TABLE

ACRONYMS

B&K	Briiel and Kjær
CCl_4	carbon tetrachloride
DQO	data quality objective
INEEL	Idaho National Engineering and Environmental Laboratoq
OCVZ	organic contamination in the vadose zone
RPD	relative percent difference
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
VOC	volatile organic compound
VVET	vapor vacuum extraction with treatment

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1. INTRODUCTION

1.1 Purpose

This report documents the operational activities of Operable Unit 7-08 through the mid-year reporting period of operations for Calendar Year 2003 (i.e., January 1 through June 30, 2003). Operable Unit 7-08 is defined as the Organic Contamination in the Vadose Zone (OCVZ) Project at the Subsurface Disposal Area (SDA) of the Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering and Environmental Laboratory (INEEL).

Operable Unit 7-08 extends from the land surface to the top of the Snake River Plain Aquifer approximately 177 m (580 ft) beneath the RWMC. Disposal pits and trenches within the SDA are not part of Operable Unit 7-08. The vadose zone contains volatile organic compounds (VOCs) primarily in the form of organic vapors that have migrated from the buried waste in the SDA. Figures 1 and 2 are maps showing the locations of the INEEL and the SDA, respectively.

Operable Unit 7-08 is the designation recognized under the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991) and the "Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA/Superfund)" (42 USC § 9601 et seq., 1980) for OCVZ remediation beneath the RWMC, which comprises the SDA. In accordance with the *Record of Decision: Declaration for Organic Contamination in the Vadose Zone Operable Unit 7-08, Idaho National Engineering Laboratory, Radioactive Waste Management Complex, Subsurface Disposal Area* (DOE-ID 1994) (hereafter referred to as *OU 7-08 Record of Decision)*, the selected remedy for OCVZ consists of the extraction and destruction of organic contaminant vapors present in the vadose zone and the monitoring of vadose zone vapors in the Snake River Plain Aquifer beneath and within immediate vicinity of the RWMC.

1.2 Background

To implement the selected remedy described in the *OU 7-08 Record of Decision* (DOE-ID 1994), three vapor vacuum extraction with treatment (VVET) units with recuperative flameless thermal-oxidation systems were installed within the boundaries of the SDA and began operating in January 1996. Two of the flameless thermal-oxidation-system units (designated as Units A and B) extract and treat vapors from two extraction wells, and one flameless thermal-oxidation-system unit (designated as Unit C) extracts and treats vapors from one extraction well. During the spring of 2001, Unit C was decommissioned and removed from the SDA. Unit D, an electrically heated catalytic oxidizer, was installed at the previous Unit C location. Currently, Unit A treats vapors from Extraction Well 8901D, Unit B treats vapors from Extraction Well 2E, and Unit D treats vapors from Extraction Well 7V.

In 1994, 15 new vapor extraction and monitoring wells were installed in, or next to, the SDA. In addition, one extraction well, Well 8901D, and five monitoring wells, Wells D02, 8801, 8902, 9301, and 9302, were incorporated for extracting and monitoring VOC vapors. In 2000, Wells DE-1 and M17S were installed to provide additional monitoring. In 2001, Wells 6E and 7E were installed as extraction wells above 24 m (80 ft) below ground surface. During late 2002, Wells SE6, IE6, DE6, SE7, IE7, DE7, SE8, IES, and DES were drilled and set with casing and vapor ports. Wells SE3, IE3, DE3, IE4, and DE4 were set in early 2003. All boreholes installed during Fiscal Year 2003 were completed as extraction and/or monitoring wells

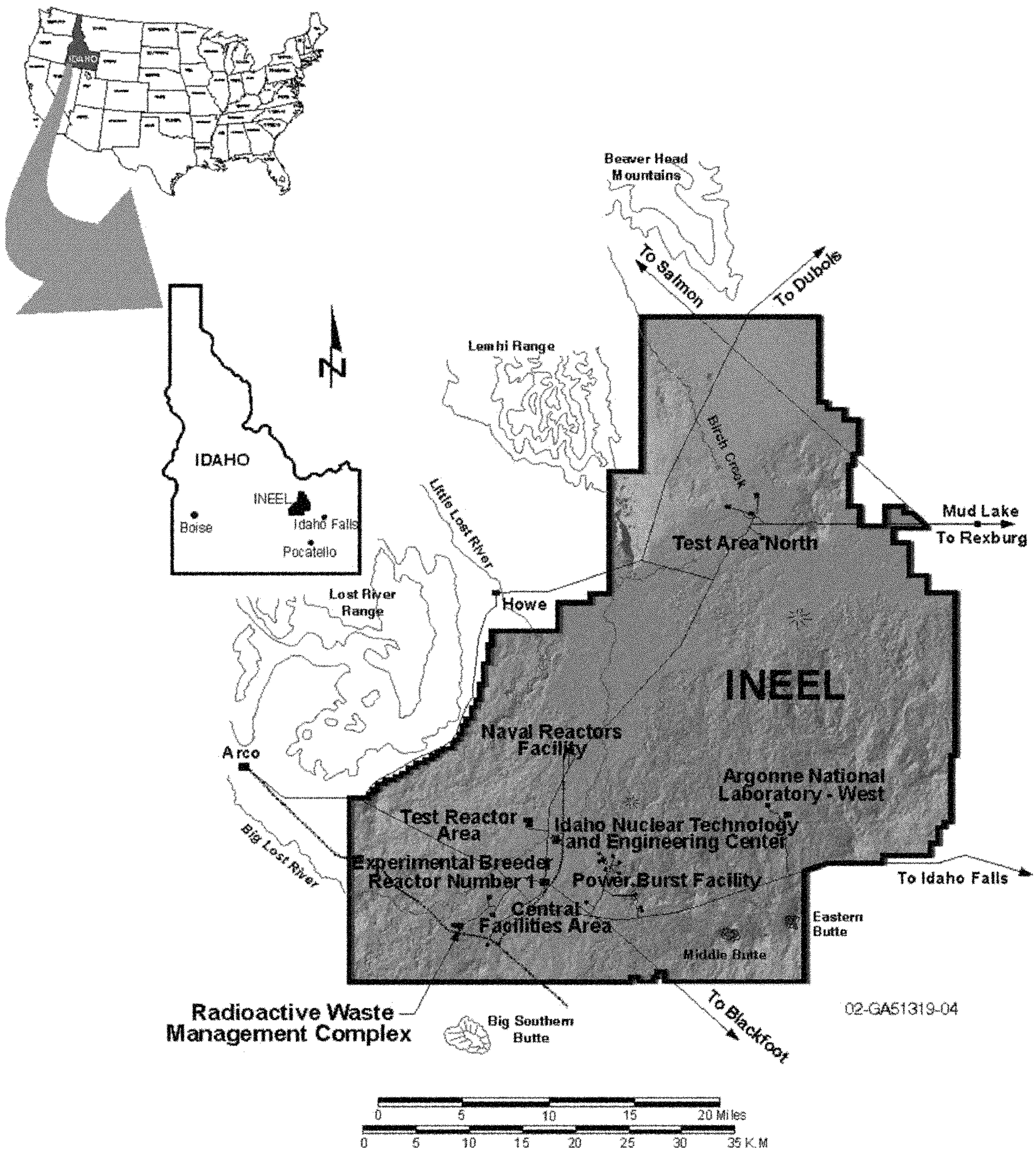

Figure 1. Map of the Idaho National Engineering and Environmental Laboratory showing the location of the Radioactive Waste Management Complex.

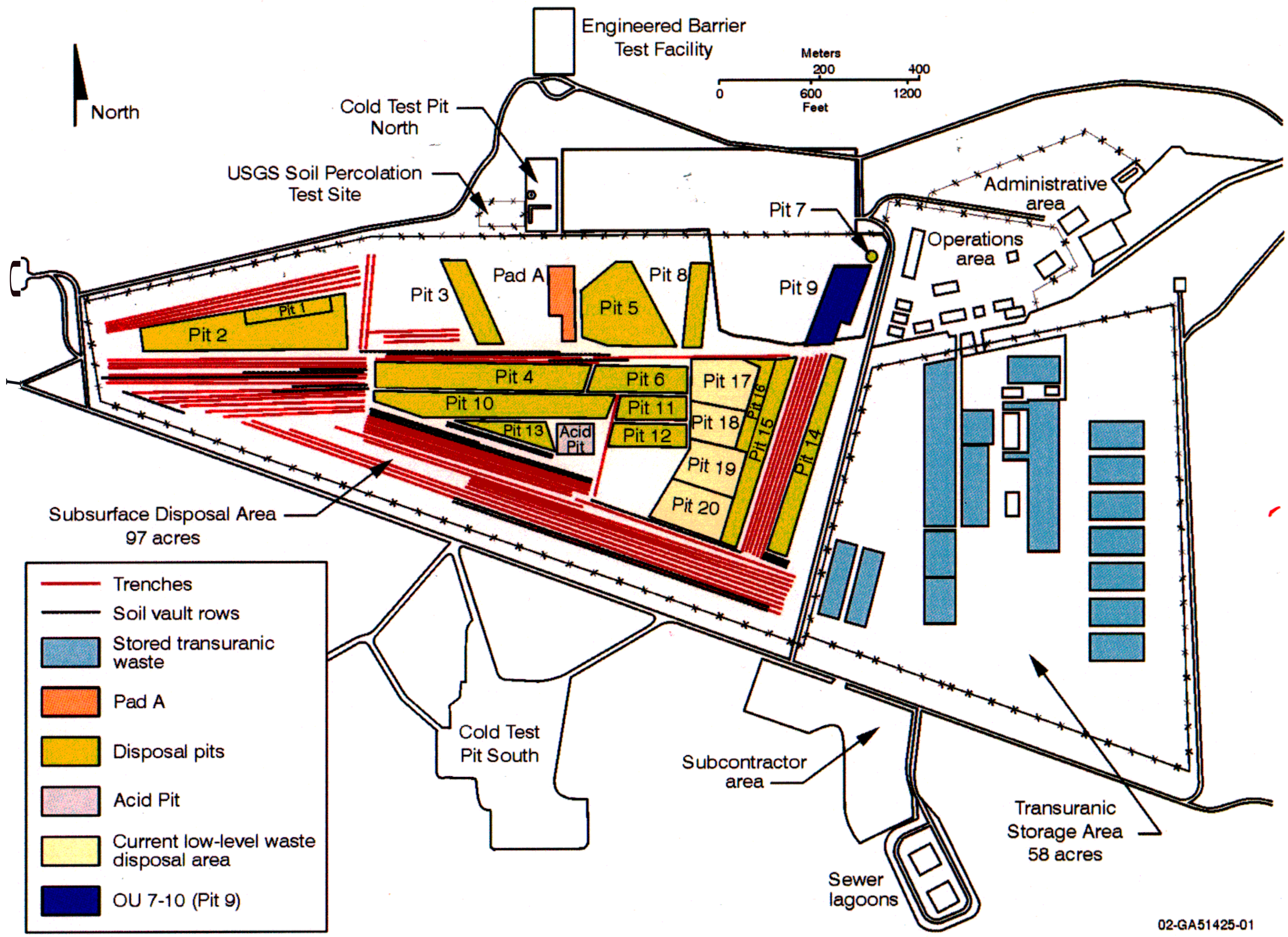

Figure 2. Map of the Radioactive Waste Management Complex showing the location of the Subsurface Disposal Area.

2. DISCUSSION OF ENVIRONMENTAL AND OPERATIONAL SAMPLE DATA

To calculate VOC mass removal rates and to monitor effectiveness of the W E T system, vapor samples are collected at the inlet of W E T units and analyzed using a Briiel and Kjær (B&K) photoacoustic multigas analyzer. This section presents a discussion of the following data quality and monitoring objectives for the project:

- Precision
- Accuracy
- Completeness
- Comparability
- Mass removal
- Spatial and temporal distribution of VOCs in the vadose zone
- System optimization and maintenance.

2.1 Precision

Precision pertains to the sharpness, definition, or focus of a particular data set. Precision implies an exact measurement with little sample-to-sample variation and high repeatability. Two types of sample replicates were analyzed to ensure the quality of collected data. The two classifications of replicates were field splits (repeat) and field duplicates. A field split is a repeat analysis of a field-collected sample used to test the precision of the analytical instrument. **A** field duplicate is a separate sample collected from the same location at the same time as the original sample. This duplicate sample is used to test the precision of the field collection techniques. Precision was determined by calculating the relative percent difference (RPD) for both the field duplicates and the field splits. A goal was set for precision of less than *30%* RPD for all replicate samples (INEEL 2002). The RPD is calculated as shown in Equation (1) where C_1 and C_2 are the respective analyte concentrations in a replicate sample pair.

$$RPD = 100 \times \frac{\left(\left|C_1 - C_2\right|\right)}{\left(\dfrac{C_1 + C_2}{2}\right)} \quad . \tag{1}$$

Samples were analyzed, as in previous operating cycles, using a B&K gas analyzer. Sample precision of duplicate or repeat samples of chloroform, 1,1,1-trichloroethane, tetrachloroethene, trichloroethene, carbon tetrachloride (CCl_4), and total VOCs were recorded (see Appendix **A).** A total of 140 sample replicates (duplicate and split [repeat] sample pairs) was collected during the operating cycle, resulting in a total of 700 possible component pairs. Of the 140 samples, 117 replicate pairs exhibited RPDs of less than 30% for all analyzed components. Of the *23* sample pairs that exceeded *30%* RPD, 17 were the result of measured analyte concentrations (for one or more components) below the 1-ppmv B&K detection limit. Measurement precision decreases as sample concentrations approach the 1-ppmv B&K detection limit, resulting in the observed increase in RPD. For any samples resulting in a negative value, the concentration was assumed to be zero.

2.2 Accuracy

Standards (i.e., premixed gas samples at verified concentrations) were purchased at concentrations of 1, 100, 500, and 1,000 ppmv. Standard gases for the 1-, 100-, and 1,000-ppmv levels expired in March and were replaced on April 1, 2003. Actual constituent concentrations of each of the standard gasses are detailed in Tables 1 and 2. These standard gasses were analyzed before each set of vapor samples was analyzed to quantify and validate instrument performance.

Table 1. Standard gas compositions used from January through March 2003.

Constituent	1-ppmv Standard	100-ppmv Standard	500-ppmv Standard	1,000-ppmv Standard
Chloroform	1.01 ppmv	100.4 ppmv	498.60 ppmv	—
1,1,1-trichloroethane	0.99 ppmv	99.8 ppmv	497.46 ppmv	—
Tetrachloroethene	1.02 ppmv	99.9 ppmv	498.25 ppmv	—
Trichloroethene	1.01 ppmv	100.1 ppmv	498.57 ppmv	—
Carbon tetrachloride	1.01 ppmv	100.5 ppmv	498.87 ppmv	998.7 ppmv

Table 2. Standard gas compositions used from April through June 2003. (Note: The same 500-ppm standard was used throughout the reporting period.)

Constituent	1-ppmv Standard	100-ppmv Standard	500-ppmv Standard	1,000-ppmv Standard
Chloroform	1.02 ppmv	100.25 ppmv	498.60 ppmv	—
1,1,1-trichloroethane	1.03 ppmv	99.81 ppmv	497.46 ppmv	—
Tetrachloroethene	1.04 ppmv	100.06 ppmv	498.25 ppmv	—
Trichloroethene	1.03 ppmv	100.23 ppmv	498.57 ppmv	—
Carbon tetrachloride	1.01 ppmv	98.55 ppmv	498.87 ppmv	1,001.2 ppmv

Accuracy pertains to the extent to which instrument readings approach the true values and are free from error. Instrument accuracy was tested using the various sample standards before analyzing each sample set during the mid-year 2003 operating period. Analytical results for the 1-ppmv CCl_4 standard sample were measured with reported concentrations ranging from 85 to 1,109% (see Section 2.2.1) of the known concentration. Analytical results for 31% of the 1.01-ppmv CCl_4 standard samples exceed the prescribed acceptable ±20% error bound limit. Analytical results for the 100-ppmv CCl_4 standard samples are much less scattered than those of the 1.01-ppmv CCl_4 standard, with results that range from 83 to 115% of the known concentration. Analytical results for the 500-ppmv CCl_4 standard sample were measured with reported concentrations ranging from 85 to 98% of the known concentration. The 1,000-ppmv CCl_4 standard samples had results that ranged from 92 to 103% of the known CCl_4 concentration. Analytical results have fallen within the acceptable ±20% error bound limit of known CCl_4 concentrations 92% of the time for all standard samples. No standard CCl_4 samples, other than those at the 1-ppm range, fell outside of the ±20% error bound limit. The accuracy of the B&K gas analyzer is illustrated in Appendix B.

2.2.1 Analytical Performance Enhancement

The project has been vigilant to maintain and improve the quality of data collected and the confidence with which these data can be used. Better quality has been achieved in analytical performance through better sampling and analysis procedures, including sample collection, handling and storage procedures, and calibration and performance optimization of existing analytical equipment.

During the mid-year 2003 operation period, the accuracy of the B&K gas analyzer was quantified, and the results showed adequate quality performance in accuracy at levels higher than at least 1 ppm. However, accuracy at lower concentrations ranges is still inadequate. Results showed that, during the first 7 weeks of the operation period, all of the l-ppm standard gases exceeded the acceptable range of +/- 20%. This was likely due to the limitations of the analyzer and improper setting of the unit's barometer. Once adjustments were made to the barometer, results improved dramatically with nearly all samples falling within the acceptable range for the remainder of the operational period.

2.3 Completeness

A total of 884 samples was targeted during the end-year 2002 period of operation. This total included 768 well samples, 77 well repeats, and 39 well duplicates. Ultimately, 856 (97% of target) samples were analyzed and recorded. This included 736 well samples, 77 well repeats, and 43 well duplicates. Repeats and duplicates were targeted for analysis rates of at least 1:10 and 1:20, respectively. Factors affecting well completeness include sample bag failure and inaccessibility to well locations. For example, a few wells were inaccessible during the winter months because of snow covering the access roads.

Percent completeness of the sampling and analytical data was calculated for this operating cycle using Equation (2). Completeness of sampling is detailed in Table 3 for monthly well monitoring and duplicate and repeat samples. Because samples are considered noncritical during VVET operations, a target for completeness of 90% is designated by the *Data Quality Objectives Summary Report for Operable Unit 7-08 Post-Record of Decision Sampling* (INEEL 2002) (hereafter referred to as OCVZ data quality objective [DQO] report).

$$\%complete = 100 \times \frac{(\text{number of samples analyzed})}{(\text{number of samples targeted})} \quad (2)$$

Table 3. Completeness of well sampling.

Type	Samples Targeted	Samples Analyzed	Percent Complete
Monthly monitoring samples	768	736	96%
Monthly duplicates	39	43	110%
Monthly splits (repeats)	77	77	100%
Total samples	**884**	**856**	**97%**

2.4 Comparability

The data set included in this report (i.e., January 1 through June 30, 2003) is comparable to that of previous data sets because the same field collection technique, field procedures, sample-handling methods, and quality assurance and quality control procedures were applied. Analytical detection limits are similar because the same field instrumentation was used (i.e., B&K gas analyzer). Duplicate field samples were targeted for collection at a rate of roughly 5% while field splits (repeats) were targeted at a rate of 10%, in accordance with the OCVZ DQO report (INEEL 2002).

On a monthly basis, samples were collected from 99 vapor ports within and in immediate vicinity of the SDA boundary to monitor concentration trends in the VOC plume. On a quarterly basis, 33 additional ports outside the SDA boundary were sampled to monitor the vapor concentrations at various locations ranging up to 2,774 m (9,100 ft) from the VOC source area. Beginning in April 2003, 36 additional vapor ports were added to the list of monthly sampling ports. Vapor port sampling and analysis were completed in accordance with the OCVZ DQO report (INEEL 2002).

The statistical analyses for precision and accuracy of four monthly vapor port sampling events (January, February, April, and May 2003) and two quarterly sampling events (March and June 2003) are included in Appendixes A and B.

2.5 Mass Removal

The VOC concentrations of process samples taken from ports on the inlet lines (downstream of the ambient air intake valves) to the VVET units were used to calculate mass removal rates. Samples were taken daily during the normal operations workweek (i.e., Monday through Thursday), and the results averaged between sampling events. The results show that approximately 4,987 kg (10,995 lb) of total VOCs were removed during this operating cycle. Units A, B, and D removed approximately 3,020; 2,770; and 996 kg (8,603; 515; and 1,877 lb), respectively. Actual operating hours and average daily unit operation parameters (i.e., flow rate, pressure, and temperature) were used for the mass removal calculations (EDF-2157).

Consistent with the analysis of well vapor samples, VVET process samples were analyzed using the B&K gas analyzer. Section 2.2 presents a discussion of analyzer accuracy.

Analyte mass removal estimates for January through June 2003 for Units A, B, and D are presented in Appendix C, Tables C-1, C-2, and C-3, respectively. Shown graphically in Figures C-1, C-2, and C-3 are process sample (i.e., inlet) CCl_4 concentrations for Units A, B, and D, respectively. For comparison, Figures C-4 and C-5 graphically present mass removal estimates for each analyte during this reporting cycle and since January 1996, respectively. Analyte mass removal estimates for each operating cycle since January 1996 are provided in Table C-4. As shown in this table, CCl_4 is the largest contributor to the mass removal of VOCs with 57% of the total occurring from January through June 2003 and 62% of the total occurring since January 1996.

2.6 Spatial and Temporal Distribution of Carbon Tetrachloride in the Vadose Zone

Spatial and temporal distribution of the CCl_4 concentration in the subsurface is graphically presented in Appendix D. The figures in Appendix D represent a horizontal cross section of the distribution of the CCl_4 concentration in the SDA at approximately 21 m (70 ft) below ground surface. Concentration values from five different sampling events were used to prepare the plots before starting remedial action in January 1996, January 1998, January 2000, January 2002, and June 2003. The CCl_4 concentration distribution was kriged" by using Environmental Visualization System software program.

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a. Kriging is a method of linear regression that takes into account the spatial relationship of a series of points. In this case, concentrations are estimated between actual measured data points, providing insight into what the actual concentration profile might look like at any horizontal level in the contamination zone.

Plots of current CCl_4 vapor data, at approximately 21 m (70 ft) deep, indicate an overall decrease in the areal extent of the plume when compared to data taken before operations at the same depth. The vapor data also indicate a decrease in the CCl_4 concentration at the center of the plume.

2.7 System Optimization and Maintenance

This section documents treatment system corrective maintenance modifications, preventive maintenance, configuration management, and component calibration activities completed from January through June 2003. Preventive maintenance activities were completed in accordance with the OCVZ VVET preventive maintenance schedule (McMurtrey and Harvego 2001).

2.7.1 Corrective Maintenance

Corrective maintenance activities are required in response to system failures or breakdowns. Work is performed in accordance with the INEEL "Integrated Work Control Process" (STD-101). During the mid-year 2003 reporting cycle, most corrective maintenance activities were performed on the propane feed system to Units A and B and are summarized the following paragraphs.

All three units were shut down on January 3,2003, for a planned power outage. Later that same day, Units A and D were restarted, but Unit B experienced problems with the burner ignitor. The burner ignitor and propane supply lines were cleaned, and Unit B was restarted on January 9,2003.

On January 10,2003, Unit B shut down because of low temperature in the oxidizer. It was determined that the regulator on the propane vaporizer was set at too low of a temperature. The regulator was adjusted, and Unit B was restarted on January 11,2003.

On January 20,2003, Unit B again shut down because of propane feed problems and low temperature. Maintenance was performed on the propane lines: the sparger was cleaned, and the valve actuation was checked. The Unit was restarted on January 23, 2003.

Unit B was shut down on February 12,2003, because the blower was making a low-pitch grinding noise during operation. After extensive troubleshooting, it was concluded that the blower needed repair or replacement because of bad bearings or rotors. A joint decision among U.S. Department of Energy Idaho Operations Office, U.S. Environmental Protection Agency, Idaho Department of Environmental Quality, and project personnel was made to accelerate the planned shutdown and dismantlement of Unit B rather than commit additional time and resources to further repair and replace components.

Unit A shut down temporarily because of high propane pressure on May 13, 2003. Propane regulation adjustments were made, and the unit was restarted later that same day.

Unit A again experienced propane pressure problems on May 19,2003. This time, the pressure had fallen too low, and the unit shutdown. Once again, propane regulation adjustments were made, and the unit was restarted that same day.

2.7.2 Preventive Maintenance

A preventive maintenance schedule has been developed to ensure that appropriate measures are taken to maximize the life of system components. The preventive maintenance schedule identifies maintenance activities to be completed at monthly, quarterly, semiannual, annual, and biannual intervals (McMurtrey and Harvego 2001). Maintenance work is planned by qualified project field personnel and executed by RWMC craft personnel. Development and implementation of preventive maintenance work packages are in conformance with the INEEL "Integrated Work Control Process" (STD-101). Project field personnel continue to make improvements on the maintenance work packages to minimize downtime of the VVET units.

During the 2003 mid-year reporting cycle, all preventive maintenance work was performed on schedule. Monthly preventive maintenance tasks were performed on Units A and D from January through June 2003. Monthly preventive maintenance tasks were performed on Unit B from January through March 2003 when a decision was made to accelerate shutdown of the system. A quarterly preventive maintenance task was performed on Unit D in March 2003. A semiannual preventive maintenance task was performed on Unit A in April 2003.

2.7.3 Configuration Management

The configuration management process provides quick access to a database of information about individual components and pieces of equipment, including the manufacturer model and serial numbers, contact address and phone numbers, and all pertinent information for repairing or replacing any component or part. The database also provides a numbering system to identify the equipment and components in the field when performing preventive maintenance or other work activities.

2.7.4 Calibration Program

Calibration is performed on system process indicators in accordance with the INEEL "Control of Measuring and Test Equipment" (MCP-2391). The process indicators, including switches, gauges, transducers, and controllers, are calibrated to ensure proper function. Gauges, switches, and transducers are tested, calibrated, and retained in controlled storage at the RWMC before installation during scheduled preventive maintenance activities.

2.7.5 Modified Unit D System Operability and Integrated Testing to the New Wells

In May 2003, construction was complete on the piping system from Unit D to Wells SE6, IE6, and DE6. Construction work included installation of insulated pipelines and fabricated pipeline supports connecting the three new wells to Unit D and installation of two new pressure transmitters (VVED-PIT-102, WED-PIT-150, and VVED-PIT-101). System operability testing under "OU 7-08 OCVZ VVET Modified Unit D System Operability and Integrated Testing" (TPR-6860) began on May 28,2003, with active extraction from the new wells. The testing under Technical Procedure-6860 concluded in mid-June 2003, and testing results indicated that 400 scfm of flow were achievable from each of the three new wells, operating independently, and multiple wells, operating concurrently. System control was successfully achieved with the pressure set point (VVED-PIT-102) at 100 in. of water column. Routine operation of VVET Unit D is proceeding with vapors being pulled from Wells SE6, IE6, and 7V. Extraction from the deep well, DE6, will be performed for short durations on a frequency to be determined by the project engineer based on subsurface vapor concentration data.

2.7.6 Radiological Filter Sampling and Analysis at the Inlet to Vapor Vacuum Extraction with Treatment Units

Weekly radiological surveys were completed on inlet filters downstream of the blowers at each of the VVET units. Results indicate that radiological contamination is not present on the filters.

2.8 Operational Uptime

During the mid-year 2003 operations period, a goal of 80% uptime of available hours was set for operation of the VVET units not including planned downtime for maintenance activities. Units A, B, and D achieved uptimes of 99.6, 94, and 100% of available hours, respectively. Appendix E contains the operations history of VVET Units A, B, C, and D.

2.8.1 Planned and Uncontrollable Downtime

Available hours equal calendar hours less planned and uncontrollable downtimes. The majority of downtimes occurring during the mid-year 2003 operations period were classified as planned downtimes. Planned downtimes included scheduled maintenance activities (corrective and preventive) and system optimizations. Dates and brief explanations of activities that resulted in planned operational shutdowns are itemized below:

- January 3,2003—All three units were shut down for a planned power outage at the RWMC.
- January 28–January 29,2003—All three units were shut down for a planned power outage at the RWMC.
- February 6, 2003—All three units were shut down for a planned power outage at the RWMC.
- February 12,2003—Unit B was shut down, and personnel began the process of dismantlement and disposition.
- February 28–March 3,2003—Units A and D were shut down for an RWMC power outage.
- March 6, 2003—Unit D was shut down temporarily for a routine quarterly maintenance.
- April 1–May 28,2003—Unit D was shut down to place a lockout/tagout on the system and begin the process of installing the electrical and new piping systems to Wells SE6, IE6, and DE6.
- April 8–April 9, 2003—Unit A was shut down for routine semiannual preventive maintenance.
- May 22–May 27,2003—Unit A was shut down for an RWMC power outage over Memorial Day weekend.
- June 12–June 30,2003—Units A and D were shut down for a power outage at the RWMC to support installation of the high-voltage power line and equipment for Unit F.

2.8.2 Unplanned Downtime

Through the operational period, Unit A had unplanned downtime of less than 1% (16.8 hours). Unit B recorded unplanned downtimes of 6% (264 hours), and Unit D had no unplanned downtimes. Dates and brief explanations of equipment failures that led to unplanned operational shutdown are itemized below:

- January 3–January 9,2003—Unit B experienced difficulties during startup because of problems with the ignition system. The burner was replaced, and the unit was restarted.

- January 10–January 11,2003 — Unit B shut down because of low temperature in the oxidizer. The regulator was adjusted, and the system was restarted on the next day.

- January 20–January 23,2003 — Unit B shut down again because of propane feed problems. The temperature in the oxidizer had dropped too low. Maintenance was performed on the components.

- February 7–February 8,2003 — Unit B shut down each day because of propane feed problems. The unit was started within a few hours following shutdown each day.

- May 13,2003 — Unit **A** shut down for a short period because of high propane pressure.

- May 19,2003 — Unit **A** shut down for a short period because of low propane pressure.

3. WELL MONITORING

Appendix F contains VOC concentrations of subsurface vapor samples collected from January through June 2003. The samples were collected from well ports located inside and in close proximity to the SDA in the RWMC at the INEEL.

Volatile Organic Compound Vapor Monitoring Results from Selected Wells ut the Radioactive WusteMunugement Complex (Housley 2003) contains all data collected from the monitoring wells from 1993 through 2002. Starting in 2003, these data will be updated and presented within the environmental and operational semiannual data reports and will contain data from the previous 6 months of monitoring. Table 4 shows the project and official names of the 56 wells that are presented in this report. Figure 3 shows the depths of the ports of each well. Figure 4 shows the location of each monitoring well in and around the RWMC.

Table 4. Organic contamination in the vadose zone wells listed by official name and project name

Inside the Subsurface Disposal Area		Outside the Subsurface Disposal Area	
Official Name	Project Name	Official Name	Project Name
RWMC-VVE-V-067	1E	IE8	IE8
RWMC-VVE-V-068	2E	DE8	DE8
RWMC-VVE-V-069	3E	VVE1	VVE1
RWMC-VVE-V-070	4E	VVE3	VVE3
RWMC-VVE-V-071	5E	VVE4	VVE4
RWMC-GAS-V-072	1V	VVE6A	VVE6
RWMC-GAS-V-073	2V	VVE7	VVE7
RWMC-GAS-V-074	3V	VVE10	VVE10
RWMC-GAS-V-075	4V	M1SA	M1S
RWMC-GAS-V-076	5V	M3S	M3S
RWMC-GAS-V-077	6V	M4D	M4D
RWMC-GAS-V-078	7V	M6S	m65
RWMC-GAS-V-079	8V	M7S	m75
RWMC-GAS-V-080	9V	MlOS	MlOS
RWMC-GAS-V-081	10V	RWMCMON-A-162	M17S
88-01D	8801	SOUTH-MON-A-001	M11S
89-02D	8902	SOUTH-MON-A-003	M13S
9301	9301	SOUTH-MON-A-004	M14S
9302	9302	SOUTH-MON-A-009	M15S
RWMC-VVE-V-163	DE1	SOUTH-MON-A-010	M16S
IE3	IE3	SOUTH-GAS-V-005	OCVZ11
DE3	DE3	SOUTH-GAS-V-007	OCVZ13
IE4	IE4	SOUTH-GAS-V-008	OCVZ14
DE4	DE4	USGS 118	USGS118
IE6	IE6	WWW1	WWW1
DE6	DE6	77-1	77-1
IE7	IE7	78-4	78-4
DE7	DE7	D-02	D02

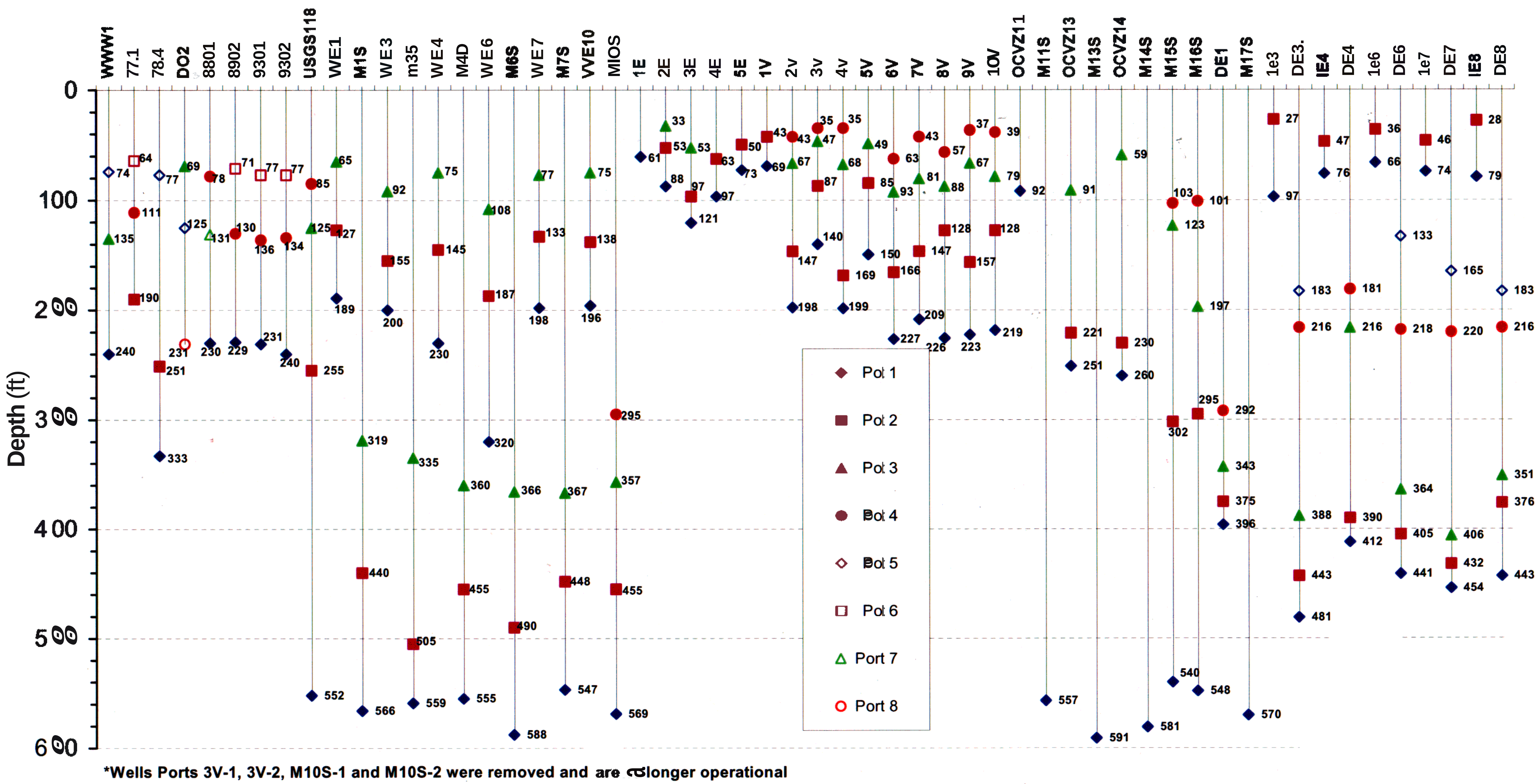

Figure 3. Port depths of the Operable Unit 7-03 monitoring wells.

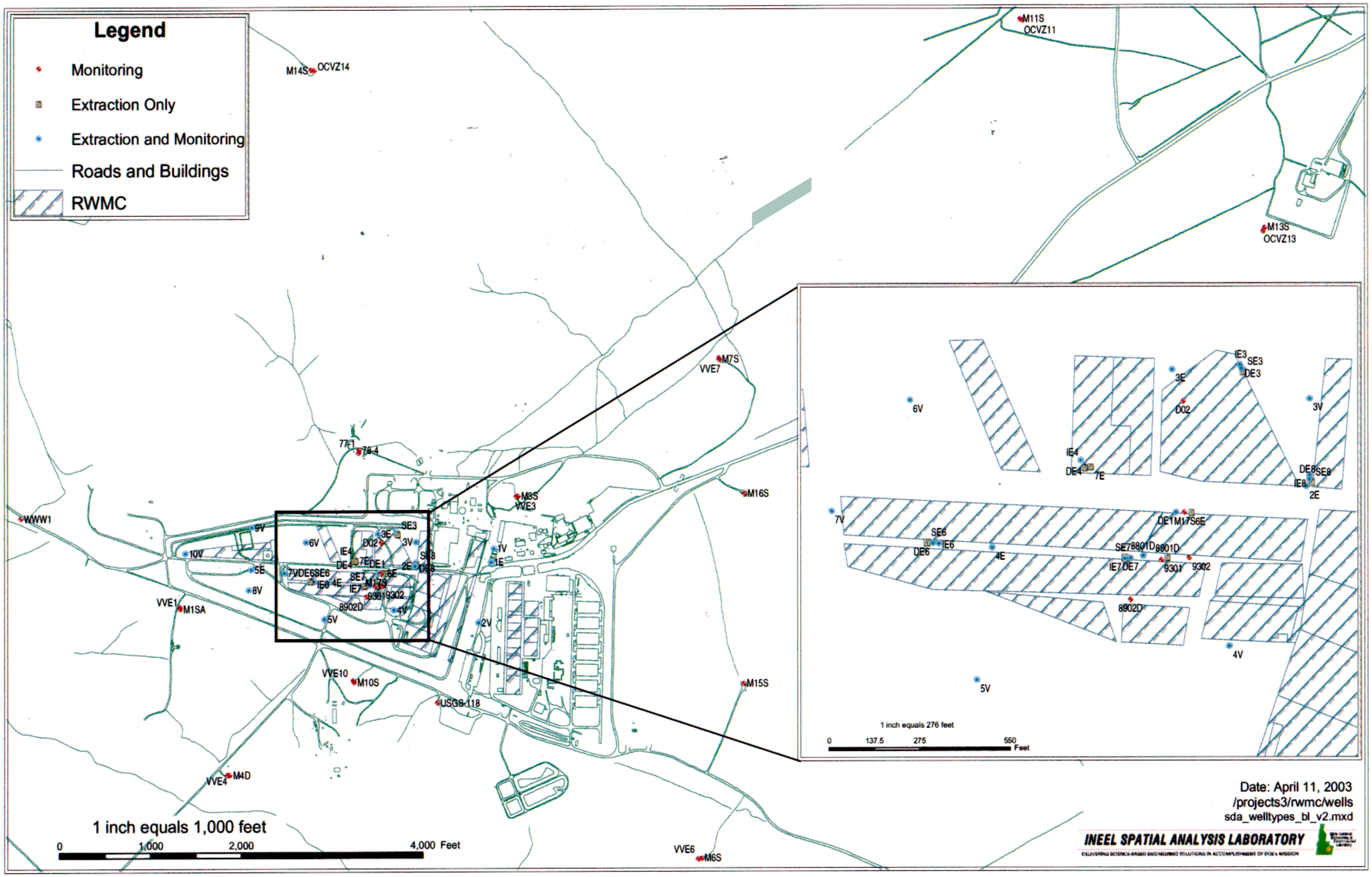

Figure 4. Operable Unit 7-08 vapor monitoring and extraction wells inside and outside the Subsurface Disposal Area.

4. CONCLUSION

Data quality and monitoring objectives include completeness, precision, and accuracy as outlined in the OCVZ DQO report. The target for completeness was generally met. Issues affecting instrument analytical accuracy and precision have been identified and corrected. To date, Units A, B, and D are operating and removing VOC mass from the RWMC subsurface. According to samples collected from various locations around the SDA, VOC concentrations are decreasing above the 34-m (110-ft) interbed.

Data quality and monitoring objectives include completeness, precision, and accuracy as outlined in the OCVZ DQO report. The target for completeness was generally met. Issues affecting instrument analytical accuracy and precision have been identified and corrected. To date, Units A and D are operating and removing VOC mass from the RWMC subsurface. Unit B was permanently shut down in February to be replaced with a new electrically heated catalytic oxidizer. General trends show a decreasing areal extent of the plume of VOCs. Occasionally, short-term, intermittent increases of VOC concentrations are observed at various locations and depths around the SDA. These increases are often sporadic and difficult to explain. The prevailing long-term trends, however, indicate that overall VOC concentrations are decreasing above the 34-m (110-ft) interbed when compared to data taken before operations at the same depth.

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Appendix A

Sampling and Analysis Precision

Appendix A

Sampling and Analysis Precision

To calculate mass removal rates of VOCs and to monitor effectiveness of the VVET system at the SDA, vapor samples were collected at the inlet of the VVET units and analyzed using a B&K photoacoustic multigas analyzer. Tables A-1 and A-2 show the precision of duplicate or repeat samples of chloroform, 1,1,1-trichloroethane, tetrachloroethene, trichloroethene, CCl_4, and total VOCs for the mid-year 2003 operational period.

Table A-1. Monthly vapor sample precision—repeats.

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)
	9:15:46 AM	4.87	3.39	12.6	4.99	11.3
	9:18:06 AM	5.01	3.3	12.6	4.99	11.3
RPD		2.83%	2.69%	0.00%	0.00%	0.00%
	9:41:27 AM	4.63	4.27	0.793	2.5	5.89
	9:43:44 AM	4.75	4.2	0.757	2.44	5.95
RPD		2.56%	1.65%	4.65%	2.43%	1.01%
	10:08:17 AM	4.65	45.2	0.636	5.25	7.16
	10:10:33 AM	4.76	46.7	0.628	5.35	7.26
RPD		2.34%	3.26%	1.27%	1.89%	1.39%
	10:34:08 AM	8.33	63.5	0.983	10.4	16.1
	10:36:20 AM	8.5	64.6	1.01	10.5	16.1
RPD		2.02%	1.72%	2.71%	0.96%	0.00%
	10:56:52 AM	77.4	81.2	17.8	31.7	97.9
	10:59:13 AM	77.9	81.5	18	32.4	99.1
RPD		0.64%	0.37%	1.12%	2.18%	1.22%
	11:22:15 AM	1.72	1.18	0.118	0.306	0.293
	11:24:58 AM	1.84	1.08	0.164	0.253	0.178
RPD		6.74%	8.85%	32.62%	18.96%	48.83%
	11:45:42 AM	6.08	43.7	0.779	6.34	8.81
	11:47:54 AM	6.1	43.9	0.773	6.43	8.84
RPD		0.33%	0.46%	0.77%	1.41%	0.34%
	12:10:52 PM	3	5.31	0.331	1.46	2.35
	12:13:04 PM	2.9	4.71	0.225	1.19	2.02
RPD		3.39%	11.98%	38.13%	20.38%	15.10%
	12:36:08 PM	3.52	3.9	0.607	2.37	4.92
	12:38:20 PM	3.73	3.44	0.606	2.29	4.84
RPD		5.79%	12.53%	0.16%	3.43%	1.64%
	1:01:15 PM	224	105	7.92	114	1230
	1:03:35 PM	226	105	8.09	115	1240
RPD		0.89%	0.00%	2.12%	0.87%	0.81%
	12:31:46 PM	69.1	18.8	4.58	64.6	194
	12:33:58 PM	69.5	18.7	4.49	65	193
RPD		0.58%	0.53%	1.98%	0.62%	0.52%

Table A-1. (continued).

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)
	9:30:15 AM	46.6	11.5	3.73	35.9	107
	9:32:33 AM	46.5	11.5	3.41	35.9	107
RPD		0.21%	0.00%	8.96%	0.00%	0.00%
	9:51:36 AM	13.3	14.5	9.77	27.3	37.7
	9:53:53 AM	13.3	14.5	9.91	27.4	37.9
RPD		0.00%	0.00%	1.42%	0.37%	0.53%
	9:25:43 AM	56.4	16.7	5.02	46.7	172
	9:27:57 AM	56.4	16.7	4.82	46.7	172
RPD		0.00%	0.00%	4.07%	0.00%	0.00%
	10:29:21 AM	70.1	20.7	5.65	65.5	225
	10:31:36 AM	70.3	20.7	5.5	66	227
RPD		0.28%	0.00%	2.69%	0.76%	**0.88%**
	10:50:41 AM	11.2	10.8	7.63	21.5	30.7
	10:52:57 AM	11.2	10.8	7.59	21.4	30.6
RPD		0.00%	0.00%	0.53%	0.47%	0.33%
	8:43:54 AM	37.3	7.38	2.09	23.2	70.7
	8:46:14 AM	37.7	7.51	1.96	23.6	71.7
RPD		1.07%	1.75%	6.42%	1.71%	1.40%
	9:09:31 AM	3	1.67	0.54	0.599	2.46
	9:12:06 AM	3.18	1.52	0.533	0.637	2.48
RPD		5.83%	9.40%	1.30%	6.15%	0.81%
	9:25:47 AM	1.61	2.15	0.24	0.274	0.159
	9:28:00 AM	1.52	2.23	0.226	0.29	0.139
RPD		5.75%	3.65%	6.01%	5.67%	13.42%
	9:54:52 AM	2.09	1.54	0.342	1.02	2.67
	9:57:05 AM	2.06	1.42	0.316	1.08	2.67
RPD		1.45%	8.11%	7.90%	5.71%	0.00%
	10:20:00 AM	3.56	3.71	1.33	4.13	6.83
	10:22:25 AM	3.62	3.59	1.31	3.9	6.39
RPD		1.67%	3.29%	1.52%	5.73%	6.66%
	10:40:35 AM	9.44	4.1	0.69	8.34	13.9
	10:43:09 AM	9.51	4.25	0.674	8.51	14
RPD		0.74%	3.59%	2.35%	2.02%	0.72%

Table A-1. (continued).

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)
	10:54:18 AM	4.75	6.19	1.57	3.87	6.76
	10:56:28 AM	4.9	6.29	1.55	4.03	6.81
RPD		3.11%	1.60%	1.28%	4.05%	0.74%
	11:28:48 AM	2.03	2.63	0.569	1.58	2.2
	11:31:00 AM	1.94	2.62	0.543	1.49	2.08
RPD		4.53%	0.38%	4.68%	5.86%	5.61%
	11:53:49 AM	1.51	1.46	0.116	0.306	0.559
	11:56:01 AM	1.61	1.3	0.143	0.223	0.493
RPD		6.41%	11.59%	20.85%	31.38%	12.55%
	12:20:59 PM	135	40.7	4.01	105	494
	12:23:34 PM	136	41	4.12	107	500
RPD		0.74%	0.73%	2.71%	1.89%	1.21%
	12:44:45 PM	46.2	21.8	2.24	50.3	252
	12:49:14 PM	47.4	21.7	2.24	50.5	263
RPD		2.56%	0.46%	0.00%	0.40%	4.27%
	8:33:22 AM	52.1	15.7	4.77	42.4	169
	8:35:39 AM	52.4	15.8	4.46	42.5	170
RPD		0.57%	0.63%	6.72%	0.24%	0.59%
	9:21:21 AM	74.9	22.1	5.65	77.3	235
	9:23:43 AM	74.9	22.2	5.54	78.2	237
RPD		0.00%	0.45%	1.97%	1.16%	0.85%
	9:39:58 AM	11.7	9.5	6.59	18.1	27.2
	9:42:27 AM	11.7	9.56	6.55	18.2	27.2
RPD		0.00%	0.63%	0.61%	0.55%	0.00%
	10:00:12 AM	68.2	18	5.53	60.7	182
	10:02:31 AM	68.2	17.9	5.36	61.1	183
RPD		0.00%	0.56%	3.12%	0.66%	0.55%
	11:15:50 AM	59.7	14.9	4.03	51.2	146
	11:18:14 AM	59.8	14.7	3.87	51.3	146
RPD		0.17%	1.35%	4.05%	0.20%	0.00%
	10:44:31 AM	4.07	1.89	1.33	8.56	13.8
	10:47:06 AM	4.04	1.83	1.3	8.22	13.5
RPD		0.74%	3.23%	2.28%	4.05%	2.20%

Table A-1. (continued).

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)
	11:08:43 AM	4.03	3.48	1.34	5.5	9.58
	11:10:56 AM	4.03	3.48	1.36	5.48	9.53
am		0.00%	0.00%	1.48%	0.36%	0.52%
	11:34:08 AM	2.93	2.5	0.616	2.52	5.75
	11:36:54 AM	2.96	2.48	0.646	2.38	5.71
am		1.02%	0.80%	4.75%	5.71%	0.70%
	11:59:34 AM	44.8	27.4	7.33	26.4	217
	12:01:56 PM	45	27.5	7.42	26.5	219
am		0.45%	0.36%	1.22%	0.38%	0.92%
	12:25:08 PM	13.4	9.57	2.97	49.6	76.4
	12:27:36 PM	13.4	9.55	2.87	50.4	77.2
am		0.00%	0.21%	3.42%	1.60%	1.04%
	12:51:37 PM	63.2	42.5	13.7	20.8	80.4
	12:53:52 PM	63.5	42.5	13.9	20.7	80.7
am		0.47%	0.00%	1.45%	0.48%	0.37%
	1:16:56 PM	2.32	1.21	0.58	1.92	2.8
	1:19:11 PM	2.35	1.07	0.602	1.86	2.53
am		1.28%	12.28%	3.72%	3.17%	10.13%
	10:05:02 AM	58.2	14.3	4.57	48.1	140
	10:07:22 AM	58	14.2	4.38	48	140
am		0.34%	0.70%	4.25%	0.21%	0.00%
	8:49:55 AM	3.53	1.33	0.608	0.578	0.412
	8:52:13 AM	3.52	1.27	0.546	0.503	0.332
am		0.28%	4.62%	10.75%	13.88%	21.51%
	9:15:28 AM	2.3	1.89	0.256	0.392	0.427
	9:18:00 AM	2.32	1.8	0.2	0.369	0.337
am		0.87%	4.88%	24.56%	6.04%	23.56%
	9:30:17 AM	2.83	1.57	0.251	0.333	1.47
	9:32:29 AM	2.79	1.43	0.34	0.246	1.49
am		1.42%	9.33%	30.12%	30.05%	1.35%
	9:58:11 AM	2.42	1.9	0.213	0.234	0.216
	10:00:53 AM	2.41	1.76	0.161	0.231	0.219
am		0.41%	7.65%	27.81%	1.29%	1.38%

Table A-1. (continued).

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)
	10:23:14 AM	3.11	1.93	0.267	0.565	1.56
	10:25:26 AM	3.08	1.92	0.254	0.552	1.53
RPD		0.97%	0.52%	4.99%	2.33%	1.94%
	10:54:53 AM	2.59	1.78	0.0985	0.207	0.0001
	10:57:03 AM	2.66	1.71	0.126	0.22	0.0001
RPD		2.67%	4.01%	24.50%	6.09%	0.00%
	11:22:03 AM	3.69	2.57	0.223	0.772	1.08
	11:24:12 AM	3.73	2.59	0.258	0.902	1.03
RPD		1.08%	0.78%	14.55%	15.53%	4.74%
	9:53:08 AM	59.5	15.7	4.32	47.9	160
	9:55:25 AM	59.6	15.7	4.24	48	160
RPD		0.17%	0.00%	1.87%	0.21%	0.00%
	9:35:42 AM	57.9	18	4.79	49.7	193
	9:38:22 AM	57.6	18.1	4.71	50	195
RPD		0.52%	0.55%	1.68%	0.60%	1.03%
	9:13:49 AM	12.3	10.2	6.98	19.1	30.3
	9:16:04 AM	12.4	10.4	6.96	19.1	30.2
RPD		0.81%	1.94%	0.29%	0.00%	0.33%
	2:26:50 PM	2.25	2.86	1.24	1.48	4.93
	2:29:24 PM	2.27	2.95	1.08	1.45	4.9
RPD		0.88%	3.10%	13.79%	2.05%	0.61%
	2:52:48 PM	1.35	0.98	0.371	0.247	1.57
	2:54:59 PM	1.46	0.866	0.376	0.262	1.55
RPD		7.83%	12.35%	1.34%	5.89%	1.28%
	3:18:23 PM	3.02	2.82	0.859	2.78	7.7
	3:20:35 PM	3.03	2.78	0.785	2.8	7.76
RPD		0.33%	1.43%	9.00%	0.72%	0.78%
	3:43:24 PM	3.4	3.98	1.13	4.13	7.6
	3:45:38 PM	3.51	3.97	1.06	4.09	7.48
RPD		3.18%	0.25%	6.39%	0.97%	1.59%
	10:51:20 AM	7.8	5.65	2.47	8.26	29.4
	10:53:37 AM	7.9	5.71	2.37	8.16	29.5
RPD		1.27%	1.06%	4.13%	1.22%	0.34%

Table A-1. (continued).

	Time	CHCl$_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl$_4$ (ppmv)
	11:17:27 AM	621	99.1	13.9	393	1240
	11:19:57 AM	625	99.8	14.1	402	1260
am		0.64%	0.70%	1.43%	2.26%	1.60%
	11:43:54 AM	5.71	3.21	1.28	8.67	16.5
	11:46:41 AM	5.59	3.15	1.26	7.72	15.2
am		2.12%	1.89%	1.57%	11.59%	8.20%
	12:07:42 PM	6.46	2.21	0.506	8.14	11.1
	12:09:56 PM	6.4	2.18	0.487	8.09	10.8
am		0.93%	1.37%	3.83%	0.62%	2.74%
	12:32:44 PM	3.5	2.95	0.535	1.95	7.53
	12:35:11 PM	3.45	2.92	0.486	1.81	7.38
am		1.44%	1.02%	9.60%	7.45%	2.01%
	12:58:14 PM	5.28	2.81	0.928	5.32	11.3
	1:00:27 PM	5.39	2.74	0.965	5.32	11.3
am		2.06%	2.52%	3.91%	0.00%	0.00%
	1:21:03 PM	3.49	3.04	0.577	2.08	3.57
	1:23:14 PM	3.61	2.99	0.555	2.08	3.51
am		3.38%	1.66%	3.89%	0.00%	1.69%
	1:43:37 PM	17.4	10.2	2.3	16.8	67.5
	1:46:26 PM	18.7	9.76	2.95	17.6	57.5
am		7.20%	4.41%	24.76%	4.65%	16.00%
	2:10:59 PM	3.79	3.96	6.26	1.74	3.13
	2:13:13 PM	3.76	3.93	6.37	1.7	3.01
am		0.79%	0.76%	1.74%	2.33%	3.91%
	9:30:34	45.5	10.4	3.94	36.9	95.5
	9:32:52 AM	45.2	10.3	3.69	36.8	95.1
am		0.66%	0.97%	6.55%	0.27%	0.42%
	8:38:15	72.4	20	5.8	61.9	203
	8:40:33 AM	72.4	20.1	5.63	62.1	203
am		0.00%	0.50%	2.97%	0.32%	0.00%
	8:25:48	61.9	19.7	5.66	53.2	205
	8:28:04 AM	61.8	19.6	5.49	53.6	206
am		0.16%	0.51%	3.05%	0.75%	0.49%

Table A-1. (continued).

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)
	9:00:25 AM	3.86	2.97	1.43	4.51	9.39
	9:03:24 AM	3.75	2.86	1.34	4.41	9.02
RPD		2.89%	3.77%	6.50%	2.24%	4.02%
	9:39:23 AM	12.2	4.47	1.86	10.7	26
	9:42:23 AM	12.2	4.54	1.85	10.5	25.7
RPD		0.00%	1.55%	0.54%	1.89%	1.16%
	9:59:56 AM	1.51	2.1	1.04	0.948	4.36
	10:02:56 AM	1.45	1.95	0.937	1.03	4.35
RPD		4.05%	7.41%	10.42%	8.29%	0.23%
	10:21:22 AM	2.93	1.52	0.486	2.78	4.71
	10:24:22 AM	2.86	1.43	0.467	2.59	4.4
RPD		2.42%	6.10%	3.99%	7.08%	6.81%
	10:26:56 AM	2.24	2.43	0.82	1.57	5.2
	10:29:55 AM	2.17	2.51	0.828	1.66	5.2
RPD		3.17%	3.24%	0.97%	5.57%	0.00%
	10:54:21 AM	4.85	5.15	1.63	4.16	7.44
	10:57:21 AM	4.91	5.27	1.65	3.94	7.18
RPD		1.23%	2.30%	1.22%	5.43%	3.56%
	11:05:54 AM	1.07	1.39	0.333	0.335	0.42
	11:08:55 AM	1.09	1.3	0.252	0.209	0.26
RPD		1.85%	6.69%	27.69%	46.32%	47.06%
	11:33:20 AM	28.3	54.2	27.2	95.3	139
	11:36:20 AM	28.4	54.6	28	97.3	140
RPD		0.35%	0.74%	2.90%	2.08%	0.72%
	12:09:19 PM	26.8	16.8	5.6	28.1	84.9
	12:12:19 PM	27.2	16.8	5.69	28.5	86.1
RPD		1.48%	0.00%	1.59%	1.41%	1.40%
	12:48:17 PM	3.06	2.71	0.644	2.36	3.89
	12:51:17 PM	3.22	2.57	0.637	2.06	3.2
RPD		5.10%	5.30%	1.09%	13.57%	19.46%
	1:21:16 PM	13.6	9.48	3.86	14.5	40.3
	1:24:16 PM	13.2	9.4	3.85	14.8	40.9
RPD		2.99%	0.85%	0.26%	2.05%	1.48%

Table A-1. (continued).

	Time	$CHCl_3$ (ppɹnu)	1,1,1-TCA (ppɹnu)	PCE (ppɹnu)	TCE (ppɹnu)	CCl_4 (ppɹnu)
	1:57:15 PM	d.O3	4.55	1.18	4.36	9.73
	2:00:15 PM	d.OS	4.45	1.2	4.32	9.55
am		0.50%	2.22%	1.68%	0.92%	1.87%
	2:36:14 PM	21	15.8	4.87	24.1	79.7
	2:39:14 PM	21.1	15.8	4.96	24.5	80.9
am		0.48%	0.00%	1.83%	1.65%	1.49%
	9:43:Id	6d.I	16.5	4.97	SS.7	156
	9:46:14 AM	64.2	16.6	4.83	56.4	IS7
am		0.16%	0.60%	2.86%	1.25%	0.64%
	12:24:00 PM	3.22	2.38	0.567	1.3	3.94
	12:27:00 PM	3.I7	2.52	0.536	1.35	3.86
am		1.56%	5.71%	5.62%	3.77%	2.05%
	12:57:00 PM	2.47	2.01	O.ZSd	0.46	1.18
	1:00:00 PM	2.38	1.93	0.248	0.504	1.16
am		3.71%	4.06%	2.39%	9.13%	1.71%
	1:30:00 PM	2.03	1.65	0.0895	0.22	O.Ed
	1:33:00 PM	2.06	1.64	0.0519	0.125	0.358
am		1.47%	0.61%	53.18%	55.07%	5.16%
	2:03:00 PM	2.57	1.32	0.105	0.145	-0.04
	2:06:00 PM	2.58	1.24	0.0413	0.14	-0.082
am		0.39%	6.25%	87.08%	3.51%	0.00%
	2:36:00 PM	d.Id	4.28	0.92	3.5	13.5
	2:39:00 PM	d.Id	4.59	0.967	3.59	I3.7
am		0.00%	6.99%	4.98%	2.54%	1.47%
	3:09:00 PM	2.65	2.41	O.ZdS	0.765	1.72
	3:12:00 PM	2.82	2.29	0.308	0.77	1.69
am		6.22%	5.11%	22.78%	0.65%	1.76%
	7:32:04 AM	IO.Z	4.92	1.87	18.4	29.3
	7:35:04 AM	IO.Z	4.95	1.83	I7.d	28
am		0.00%	0.61%	2.16%	5.59%	4.54%
	7:56:03 AM	18.7	6.63	2.5	22.6	48.4
	7:59:03 AM	19	6.72	2.5	22.6	48.3
am		1.59%	1.35%	0.00%	0.00%	0.21%

Table A-1. (continued).

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)
	8:38:02 AM	7.53	7.21	2.1	9.17	21.2
	8:41:02 AM	7.67	7.37	2.01	9.06	21.1
RPD		1.84%	2.19%	4.38%	1.21%	0.47%
	9:08:01 AM	10.8	7.06	2.92	8.83	24.6
	9:11:01 AM	10.8	7.03	2.95	8.7	24.4
RPD		0.00%	0.43%	1.02%	1.48%	0.82%
	9:47:00 AM	7.2	4.82	1.25	8.09	21.6
	9:50:00 AM	7.13	4.97	1.16	8.19	21.6
RPD		0.98%	3.06%	7.47%	1.23%	0.00%
	10:19:59 AM	3.57	1.99	0.399	1.82	3.18
	10:22:59 AM	3.54	2.19	0.338	1.82	3.17
RPD		0.84%	9.57%	16.55%	0.00%	0.31%
	10:52:57 AM	3.77	2.92	0.626	1.26	3.25
	10:55:58 AM	3.67	2.93	0.567	1.29	3.18
RPD		2.69%	0.34%	9.89%	2.35%	2.18%
	11:28:57 AM	27.4	11.6	3.32	31.5	96.7
	11:31:57 AM	27.4	11.7	3.37	31.6	97.1
RPD		0.00%	0.86%	1.49%	0.32%	0.41%
	12:13:55 PM	6.7	2.99	0.947	3.1	4.33
	12:16:55 PM	6.87	2.88	0.873	2.92	4.11
RPD		2.51%	3.75%	8.13%	5.98%	5.21%
	12:46:54 PM	9.98	10.3	3.07	6.82	43
	12:49:54 PM	9.98	10.3	3.07	6.82	43
RPD		0.00%	0.00%	0.00%	0.00%	0.00%
	9:14:02	44.3	10.7	2.89	31.9	99.3
	9:17:02 AM	44.3	10.7	2.84	32	99.6
RPD		0.00%	0.00%	1.75%	0.31%	0.30%

1,1,1-TCA = 1,1,1-trichloroethane
CCl_4 = carbon tetrachloride
$CHCl_3$ = chloroform
PCE = tetrachloroethene
TCE = trichloroethene

Table A-2 Monthly vapor sample precision—duplicates

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	
	9:08:49	1.81	1.96	1.11	0.969	2.37	
	9:11:04	2.38	3.98	1.09	1.56	4.82	
RPD		27.21%	68.01%	1.82%	46.74%	68.15%	211.9[illegible]%
	9[illegible]0[illegible]1	1.43	2.7	[illegible].555	0.563	0.571	
	9[illegible]2[illegible]40	1.56	2.62	[illegible].438	0.449	0.355	
RPD		8.70%	3.01%	2[illegible].56%	22.53%	46.65%	104.45%
	13:[illegible]:47	13.4	39.5	0.505	13.7	36.1	
	13:[illegible]:08	11.1	28	0.369	9.64	24	
RPD		18.78%	34.07%	31.12%	34.79%	40.27%	159.03%
	10[illegible]9:17	10.7	49.5	1.78	13.6	27.7	
	10[illegible]31:35	8.85	36.7	1.41	10.6	20.4	
RPD		18.93%	29.70%	23.20%	24.79%	30.35%	126.97%
	9:56:42	4.31	2.23	0.907	2.57	4.72	
	9:58:56	3.98	3.53	0.502	2.2	4.78	
RPD		7.96%	45.14%	57.49%	15.51%	1.26%	127.36%
	[illegible]:04:07	7.96	41.3	1.14	8.58	16.3	
	[illegible]:06[illegible]5	9.82	36.4	1.38	9.73	21.2	
RPD		20.92%	12.61%	19.05%	12.56%	26.13%	91.28%
	10:08:44	2.71	2.89	0.612	1.56	5.09	
	10:10:57	2.59	3.55	0.62	1.55	5.58	
RPD		4.53%	20.50%	1.30%	0.64%	9.18%	36.15%
	9:00:0[illegible]	1.52	1.89	0.514	[illegible].636	0.642	
	9:02:5[illegible]	1.52	1.71	0.437	[illegible].5	0.338	
RPD		0.00%	10.00%	16.19%	2[illegible].94%	62.04%	112.18%
	11:58:12	3.93	1.63	0.741	2.31	3.79	
	12:00[illegible]2	3.82	2.58	0.331	2.18	4.93	
RPD		2.84%	45.13%	76.49%	5.79%	26.15%	156.40%
	10:01:29	7.53	6.13	1.81	8.98	19.4	
	10:04:17	8.39	7.15	2.1	10.2	23.3	
RPD		10.80%	15.36%	14.83%	12.72%	18.27%	71.9[illegible]%
	10:34:01	4.1	3.85	0.967	4.11	9.09	
	10:36:14	4.38	3.31	0.924	4.16	9.74	
RPD		6.60%	15.08%	4.55%	1.21%	6.90%	34.35%

Table A-2. (continued).

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	
	12:44:45	46.2	21.8	2.24	50.3	252	
	12:47:03	47.3	21.7	2.29	50.2	262	
am		2.35%	0.46%	2.21%	0.20%	3.89%	9.11%
	12:39:43	355	157	29.9	393	2620	
	12:42:13	400	168	33.4	452	2870	
am		11.92%	6.77%	11.06%	13.96%	9.11%	52.82%
	10:32:33	12.5	7.25	5.08	24.6	47.1	
	10:34:49	10.8	6.8	4.07	19.5	38.1	
am		14.59%	6.41%	22.08%	23.13%	21.13%	87.33%
	11:55:05	9.97	6.06	1.93	11.5	29.6	
	11:57:25	10.9	6.86	2.24	12.6	32.9	
am		8.91%	12.38%	14.87%	9.13%	10.56%	55.85%
	9:41:36	2.37	1.54	0.157	0.268	0.516	
	9:43:48	2.42	1.53	0.205	0.186	0.492	
am		2.09%	0.65%	26.52%	36.12%	4.76%	70.14%
	10:46:00	2.73	1.94	0.073	0.274	0.0697	
	10:50:29	2.48	1.81	0.0458	0.252	-0.023	
am		9.60%	6.93%	45.79%	8.37%	0.00%	70.69%
	9:51:33	4.11	2.66	0.454	1.92	4.25	
	9:53:48	4.14	3.24	0.425	1.86	4.11	
am		0.73%	19.66%	6.60%	3.17%	3.35%	33.51%
	9:03:59	2.19	2.09	0.353	0.486	1.15	
	9:06:13	2.3	1.65	0.343	0.488	1.1	
am		4.90%	23.53%	2.87%	0.41%	4.44%	36.16%
	11:31:15	4.13	4.01	0.427	1.24	4.3	
	11:33:26	3.92	4.75	0.362	1.37	4.5	
am		5.22%	16.89%	16.48%	9.96%	4.55%	53.10%
	12:48:47	18.3	9.48	3.4	30.9	71.5	
	12:51:15	17.1	9.02	3.65	26.3	62	
am		6.78%	4.97%	7.09%	16.08%	14.23%	49.16%
	14:59:46	1.07	1	0.25	0.252	0.254	
	15:01:59	1.09	0.929	0.245	0.248	0.154	
am		1.85%	7.36%	2.02%	1.60%	49.02%	61.85%

Table A-2. (continued).

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	
	11:56:01	165	**79.8**	14	204	1140	
	11:58:27	**171**	81.9	14.5	221	1170	
am		3.57%	2.60%	3.51%	8.00%	2.60%	20.28%
	12:23:37	11.2	**7.12**	2.37	15.6	**34.5**	
	12:26:10	10.5	7.04	2.35	14.6	**31.1**	
am		6.45%	1.13%	0.85%	6.62%	10.37%	25.42%
	14:26:50	2.25	**2.86**	1.24	1.48	4.93	
	14:31:39	2.12	3.17	0.995	1.37	5.08	
am		5.95%	10.28%	21.92%	7.72%	3.00%	48.87%
	9:44:57	2.8	2.23	**1.67**	2.3	5.83	
	9:47:57	2.53	**2.27**	1.39	**2.16**	5.38	
am		10.13%	1.78%	18.30%	6.28%	8.03%	44.52%
	11:05:54	1.07	1.39	0.333	0.335	0.42	
	11:11:54	1.25	1.24	0.193	**0.175**	0.236	
am		15.52%	11.41%	53.23%	62.75%	56.10%	199.00%
	10:53:55	2.03	**2.75**	**0.727**	1.58	5.05	
	10:56:55	2.13	2.92	0.679	1.38	5.13	
am		4.81%	6.00%	6.83%	13.51%	1.57%	32.72%
	11:21:20	**26.7**	51.3	**24.7**	**87.4**	**135**	
	11:27:20	**26.8**	51.9	24.4	**88**	136	
am		0.37%	1.16%	1.22%	0.68%	0.74%	4.18%
	9:12:25	5.4	**3.65**	2.05	6.09	15.9	
	9:15:24	5.84	**3.64**	1.84	**5.61**	15.2	
am		7.83%	0.27%	10.80%	8.21%	4.50%	31.61%
	9:45:23	80.1	**35.6**	6.91	88.3	473	
	9:51:23	76.9	32.2	**6.34**	**84.3**	419	
am		4.08%	10.03%	8.60%	4.63%	12.11%	39.45%
	14:45:13	**2.87**	**1.75**	0.465	0.833	1.48	
	14:48:13	2.65	1.45	0.376	0.591	0.753	
am		7.97%	18.75%	21.17%	33.99%	65.11%	146.99%
	14:06:15	2.61	1.28	0.346	1	1.01	
	14:09:15	**1.79**	1.11	0.272	0.633	0.886	
am		37.27%	14.23%	23.95%	44.95%	13.08%	133.48%

Table A-2. (continued).

	Time	$CHCl_3$ (ppmv)	1,1,1-TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	
	10:46:58	3.62	2.71	0.659	1.8	2.93	
	10:49:58	3.6	2.75	0.613	1.35	1.79	
RPD		0.55%	1.47%	7.23%	28.57%	48.31%	86.13%
	12:01:56	26.6	50.9	17.1	76.1	131	
	12:04:55	10.3	10.2	8.01	23.3	32.7	
RPD		88.35%	133.22%	72.40%	106.24%	120.10%	520.31%
	13:01:53	3.96	2.45	1.24	2.43	2.37	
	13:04:53	3.48	2.58	0.988	2.06	2.05	
RPD		12.90%	5.17%	22.62%	16.48%	14.48%	71.65%
	9:55:59	10	7.01	3.34	9.89	30.1	
	9:58:59	10.5	6.44	2.83	9.36	28	
RPD		4.88%	8.48%	16.53%	5.51%	7.23%	42.62%
	8:02:03	86.8	28.4	5.03	90.4	329	
	8:08:03	87	28.5	4.84	90.7	327	
RPD		0.23%	0.35%	3.85%	0.33%	0.61%	5.37%
	12:06:00	3.3	3.2	0.96	1.52	6.05	
	12:09:00	3.49	3.19	0.811	1.55	5.93	
RPD		5.60%	0.31%	16.83%	1.95%	2.00%	26.69%
	13:39:00	1.95	1.44	0.0813	0.152	0.0667	
	13:42:00	1.83	1.41	0.0689	0.137	0.0589	
RPD		6.35%	2.11%	16.51%	10.38%	12.42%	47.77%
	13:57:00	2.45	1.62	0.128	0.257	0.588	
	14:00:00	2.6	1.57	0.19	0.154	0.506	
RPD		5.94%	3.13%	38.99%	50.12%	14.99%	113.18%
	14:42:00	4.06	3.43	0.604	2.12	4.51	
	14:45:00	4.14	3.5	0.654	2.37	4.55	
RPD		1.95%	2.02%	7.95%	11.14%	0.88%	23.94%
	15:36:00	2.39	1.83	0.191	0.364	0.938	
	15:39:00	2.45	1.63	0.143	0.372	0.927	
RPD		2.48%	11.56%	28.74%	2.17%	1.18%	46.14%

1,1,1-TCA = 1,1,1-trichloroethane
CCl_4 = carbon tetrachloride
$CHCl_3$ = chloroform
PCE = tetrachloroethene
TCE = trichloroethene